according to Tesch's key (Zool. Meded. Leiden, iii. 1917, p. 235), into the neighbourhood of *S. eydouxi*, M.-E., and *S. granosimana*, Miers. In the former species, as redescribed by Tesch (*l. c.* p. 150), the upper margin of the palm of the chelipeds is provided with a "distinct, horny-coloured, granulate crest," and the outer surface is very minutely granulated and has a short oblique ridge about the middle. In *S. granosimana*, of which I have examined the two syntypes, the outer surface of the palm is rather coarsely and evenly granulate, its upper margin has a low denticulate crest, the upper margin of the immovable finger is (except for a notch near the base) nearly straight, and the walking-legs have no brushes of short fur on the anterior surface of the carpus and propodus of the first three pairs as they have in *S. dehaani* and *S. boulengeri*.

The specimens of *S. boulengeri* presented to the Museum thirty-six years ago were accompanied by a note on the habits of the species by the collector, Mr. Lionel E. Adams, as follows :—"Collected at Basra, 60 miles up the Euphrates, in perfectly fresh water; burrows in the banks of the river and especially in a canal in connexion with the river, where it climbs the fibrous roots of trees laid bare to the extent of 6 or 7 feet at low tide (there being 4 or 5 feet of tide at Basra) by the aid of the large claws. Sometimes they ascend the trunks to the height of 10 feet."

VI.—*The Cirripede Genus* Stramentum (Loricula): *its History and Structure.* By Thomas H. Withers, F.G.S.

[Plates III. & IV.]

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Introduction.

Although the cirripede generally known as *Loricula* is represented by more specimens approaching completeness than is any other Cretaceous cirripede, still our knowledge of its structure has not greatly advanced since 1851, when Darwin redescribed *Loricula pulchella*, G. B. Sowerby, the first-discovered member of the genus. Particularly does this apply to the number, structure, and homologies of the capitular valves and to the peduncle when complete, on which points there have since been wide differences of opinion.

In 1913 the Geological Department of the British Museum acquired from Mr. H. T. Martin two cirripedes on a piece of chalk, which he had collected in the Niobrara series of Kansas, and which are referable to *Stramentum haworthi*, Logan, sp., a species undoubtedly congeneric with *Loricula pulchella*, G. B. Sowerby. The specimens looked unpromising enough when received, but careful development soon showed certain points of structure which enable us to add materially to our knowledge of this anomalous type. The same structural features had shortly before been discovered in the type-specimens of *Loricula darwini*, and it is on the combined material that the following study of the genus is based.

History.

Of this genus as many as nine species and two varieties have so far been described, and in most cases the species is known by more than one specimen.

The first-discovered species, *Loricula pulchella*, G. B. Sowerby (1843), was founded on a single nearly complete specimen from the Turonian (Middle Chalk) of Cuxton, Kent. It was obtained by the late Mr. N. T. Wetherell, whose collection is now in the Geological Department of the British Museum, and the specimen is registered 59,150. Darwin (1851) gave a masterly description of this specimen in his Monograph.

A few years later the species *L. macadami* was established by Wyville Thomson (1858) for a fine specimen from the Chalk of Antrim, and some obscure fragments of others of a group are said to be scattered through the matrix. This specimen supplements in many ways that of *L. pulchella*, and, although it added much to our knowledge of the structure of the shell, it has not been referred to by any later author *.

In 1878 W. Dames described a single specimen from the Cenomanian (Lower Chalk) of Lebanon, Syria, under the name *L. syriaca*, and the specimen was subsequently figured by Prof. Zittel (1884).

K. A. von Zittel (1884), for a single specimen from the Senonian (Upper Chalk) of Dülmen, Westphalia, founded the species *L. lævissima*. A plaster-cast of this is in the Geological Department of the British Museum, registered 59,713.

* R. Tate quotes the species among a list of fossils, Quart. Journ. Geol. Soc. London, vol. xxi. 1865, p. 30.

Anton Fritsch (1889) described and figured a series of twelve specimens, which he described as varieties of *L. pulchella*, namely *L. pulchella*, var. *gigas*, and *L. pulchella*, var. *minor*. One of them, *L. pulchella*, var. *gigas*, had already been described by Fritsch (1877) as a separate species. The specimens occurred in the Turonian (Middle Chalk) of Weissenberg, Bohemia, and were found attached to examples of the ammonites, *Ammonites peramplus* and *A. woolgari*, no less than seven individuals being attached to a single shell of the latter species.

In the same year (1889) J. F. Whiteaves described a new species under the name *L. canadensis*. It was founded on a very fine specimen collected by Mr. J. B. Tyrrell in the Cretaceous (Fort Benton group), at South Duck River, in Township 34, Range 23 W., Manitoba. Other specimens occurred, for the author stated that "A few isolated capitular plates of *L. canadensis* were also collected by Mr. Tyrrell in 1887, at the Vermilion River, in Township 24, Range 20 W., from Fort Benton Group, or lower part of the series."

S. W. Williston (1897) followed by describing a remarkably complete specimen from the Cretaceous (Niobrara group) of Kansas, under the name *Pollicipes haworthi*. That specimen was subsequently described by W. N. Logan (1897), and together with a second species, *Stramentum tabulatum*, was included in a new genus *Stramentum*.

In 1908 Dr. H. Woodward established the species *L. darwini* on three specimens obtained by Mr. G. E. Dibley in the Turonian (Middle Chalk) *Rhynchonella cuvieri*-zone of Cuxton, near Rochester, Kent, the same locality from which came the holotype of *L. pulchella*. These three specimens were attached to the cast of an ammonite, *Puchydiscus peramplus*, and are now in the Geological Department of the British Museum, registered I. 9130.

A further species, *L. expansa*, Withers (1911), has been described, and the species was founded on two left and three right scutal valves from the Upper Senonian, *Actinocamax quadratus*-zone, East Harnham, near Salisbury, Wilts. Apart from these isolated valves it can be proved that *Loricula* occurs in the Senonian of England, for there is in the Geological Department of the British Museum an example of an oyster that had grown on a *Loricula*, and has thus preserved on its surface a perfect imprint of the greater part of a peduncle. This specimen came from the Senonian (Upper Chalk) of Norwich (Bayfield Coll.), and is registered 42,012.

Material (*number of specimens*).

In addition to the specimens mentioned above, there is in the Geological Department of the British Museum, registered 59,825, a fragmentary example of *L. pulchella*, which came from the Middle Chalk of Cowslip Pit, near Guildford, Surrey. It consists of about ten rows of the three median series of pedunecular plates. At least two, if not three, further fragmentary specimens of *L. pulchella* are in the Brighton Museum (Willett Collection, No. 40), on a piece of chalk from the Middle Chalk of Malling, Kent.

Of *Stramentum haworthi* from the Niobrara Chalk of Kansas, there is in the Geological Department of the British Museum, collected by Mr. H. T. Martin, (1) two comparatively large and almost complete specimens on a small yellowish slab, registered I. 15,945 ; (2) a large yellowish slab with about nine small individuals (registered In. 18,990), and a larger pinkish slab with remains of at least twenty individuals (registered In. 18,989) : in both cases the shells appear to have been attached to some strap-like organism of which only a stain remains, and almost all the specimens consist of one side of the shell with the inner surface uppermost, three or four retaining the scutum, which shows the pit for the adductor muscle.

Altogether the material known to me comprises no less than seventy individuals, and of these quite fifty represent at least one side of the shell in a fairly good state of preservation.

Name.

The name *Loricula* was first given to a cirripede by G. B. Sowerby, junr. (1843). This generic name has been widely accepted, and has been used by Darwin (1851) and every subsequent author on fossil and recent cirripedes. It is the more unfortunate that it should be preoccupied by *Loricula*, Curtis (1833), a genus established for a Hemipterid.

In 1897, W. N. Logan founded the genus *Stramentum* on two species of cirripedes occurring in the Chalk of Kansas. One of these had previously been described by Prof. Williston (1896) under the name *Pollicipes haworthi*, and it is not only because of this, but because it is the first of the two species described by Logan, and is more complete than the second species *S. tabulatum*, that *S. haworthi* is here taken as genotype of the genus *Stramentum*.

There is no room for doubt that the Kansas species, *Stramentum haworthi*, is congeneric with Sowerby's *Loricula pulchella*, and although Logan was evidently unaware that

cirripedes similar to his *Stramentum* had been described from the Cretaceous rocks of other countries, there is no option but to accept his genus *Stramentum*, since the name *Loricula* is preoccupied.

Stramentidæ, nom. nov.

This is a new name to replace that of Loriculidæ, which embraced the genera *Loricula* and *Archæolepas* (see Pilsbry, 1916, p. 14). *Archæolepas* must be removed from here (see p. 79), and for the present might more properly be included in the Scalpellidæ. Until the precise structure of the genera *Loriculina* and *Squama* is known, it is impossible to say whether they should be included in the family Stramentidæ or not, although it is more convenient to keep them there at present.

Stramentum, W. N. Logan.

1833. Non *Loricula*, Curtis, Entom. Mag. i. p. 197 (Hemipterid).
1843. *Loricula*, G. B. Sowerby, Ann. & Mag. Nat. Hist. vol. xii. p. 260.
1897. *Stramentum*, W. N. Logan, Kansas Univ. Quart. ser. A, Oct. 1897, vol. vi. No. iv. p. 188.
1898. *Stramentum*, W. N. Logan, Univ. Geol. Surv. Kansas, vol. iv., Palæont. pt. viii., Arthr. p. 498.

Diagnosis.—Shell flattened laterally. Capitulum composed of ten valves comprising paired scuta, paired upper latera, paired terga, paired carinal-latera, and a pair of linear valves homologous with the carina in other cirripedes. Peduncle with ten rows of smooth calcareous plates, five on each side, the six inner rows much elongated transversely, and the outer rows short; on their outer edges the plates of the outermost rows meet, but do *not* alternate with each other.

Genotype.—*S. haworthi*, Williston, sp.

Distribution.—Senonian (Upper Chalk): East Harnham, near Salisbury, Wilts, and Norwich, Norfolk; Dülmen, Westphalia; Kansas, U.S.A. Turonian (Middle Chalk): Cuxton, near Rochester, and Malling, Kent; near Guildford, Surrey; Black Head Bay, co. Antrim, Ireland; Weissenberg, Bohemia; Duck and Riding Mountain District, Manitoba, Canada. Cenomanian (Lower Chalk): Lebanon, Syria.

The following are the described species and varieties :—

Stramentum canadensis, Whiteaves, sp.
—— *darwini*, H. Woodward, sp.

Stramentum expansum, Withers, sp.
—— *haworthi*, Williston, sp.
—— *lævissimum*, Zittel, sp.
—— *macadami*, Wyville Thomson, sp.
—— *pulchellum*, G. B. Sowerby, jun., sp.
—— ——, G. B. Sowerby, sp., var. *gigas*, Fritsch.
—— ——, G. B. Sowerby, sp., var. *minor*, Fritsch.
—— *syriacum*, Dames, sp.
—— *tabulatum*, W. N. Logan.

Without an examination of the specimens, it is impossible to deduce from the published descriptions and their inadequate figures whether all of the above are distinct species and varieties. It has, however, been possible to examine the type-material of *S. pulchellum* and *S. darwini*, with the result that no justification appears for considering *S. darwini* to be distinct from *S. pulchellum*. The distinctions given by Dr. H. Woodward are "much greater size and more remarkable capitulum" and "the form of the scutum and the latera." Apart from the fact that all the specimens came from the same horizon and chalk-pit *, what differences are seen in the scutum appear due to the age and degree of development of the valve (see p. 73), and even the two specimens of *L. darwini* differ in this particular. No distinct differences are apparent to me in the latera, and if by "more remarkable capitulum" Dr. Woodward means in the greater obliquity of the summit of the peduncle, it must be pointed out that this is accentuated in that particular specimen merely because the scutum and upper latera have been slightly displaced and pushed down on to the upper scales of the peduncle (see Pl. III. fig. 2). *S. darwini* is therefore regarded here as a synonym of *S. pulchellum*.

With regard to the holotype of *S. macadami*, Prof. Grenville Cole very kindly took considerable trouble to find out for me its whereabouts, and recently informed me that it is preserved in the Belfast Public Art Gallery and Museum. The Curator, Mr. Deane, most kindly lent me the specimen, and an examination of it shows no characters by which it can be separated from *S. pulchellum*. Prof. Thomson stated in his description "One specific distinction is very evident,—the fusion of plates corresponding to the scutum and the scutal latus in the upper rows of the peduncle." I cannot understand this statement for the reason that none of the peduncular plates are fused, but, on the contrary, have precisely the same structure as in the several specimens of

* See G. E. Dibley, 1918, Proc. Geol. Assoc. vol. xxix. pp. 70, 87.

S. pulchellum. A MS. label is on the specimen bearing the words "*Loricula pulchella*," and I can see no characters in the specimen to make one dissent from that determination. *S. macadami* is therefore considered here to be a synonym of *S. pulchellum*.

Measurements.—The largest species appears to be *S. pulchellum*. The holotype has a length of 26·6 mm., its breadth is 15·2 mm., and the length of the scutum is 8·6 mm. This is surpassed by the two specimens (Pl. III. figs. 1, 2) originally described as *S. darwini*, for the original of fig. 1 has a length of 35·2 mm. (incomplete), a breadth of 22 mm., and a scutum 11·4 mm. in length, while the original of fig. 2 has a length of 44 mm., a breadth of 22·4 mm., and a scutum of 13·2 mm. in length and 7·6 mm. in breadth. In the latter specimen the carina is 6·8 mm. long and 2·3 mm. wide. The original of *S. macadami* has a length of 24·6 mm. and a breadth of 12·3 mm.

Of the other species the type of *S. haworthi* is said to have a length of 27 mm. and a breadth of 17 mm., and the type of *S. tabulatum* appears to be somewhat smaller; *S. canadensis* is from 14–15 mm. long and 7 mm. wide; *S. pulchellum* var. *minor* is said to attain a length of 20 mm. and *S. pulchellum*, var. *gigas*, a length of 36 mm.; *S. lævissima* has a length of 20 mm.; and *S. syriacum* is said to be one-third the length of *S. lævissima*.

Terminology and Number of Valves in the Capitulum.

Darwin had only a single specimen of the genus before him, namely, the holotype of *S. pulchellum*, and while this was nearly complete so far as the peduncle was concerned, it had only three of the capitular valves (see Pl. III. fig. 3). That on the right, owing to its shape and to the direction of its growth-lines, was considered by him to be the scutum and the adjoining plate as the first or upper latus. The remaining valve was called the second or carinal latus, but between that and the upper latus was a hiatus, believed by Darwin to have been filled by a tergum. Besides these valves he included in his restoration a carina and a rostrum, making ten valves in all, for he assumed that the other valves were paired.

The specimen of *S. macadami* figured and described by Wyville Thomson seven years later was more complete in the capitular region, and it included a valve—the tergum—not present in the holotype of *S. pulchellum*, between the upper and carinal latera, as well as two opposing linear

valves adjoining the carinal latus. Adopting Darwin's idea as to the identity of the other valves, Thomson suggested that these linear valves must represent two elements of a carina. An alternative suggestion was that if the capitulum was reversed the linear valve would be a reduced scutum, the second latus a rostral latus, the first latus an upper latus, and the scutum a carinal latus. This latter view was suggested as possible, but further reasons were given for his inclination to follow Darwin's ideas as to the identity of the valves.

Wyville Thomson's views have had no bearing on later discussions, for his paper has been entirely overlooked, and consequently his discovery of the split carina has passed unnoticed. It was only through a book-seller's catalogue that I came across the paper myself, and I then found that the discovery of the split carina in the genus, as now found in the species *S. pulchellum* and *S. haworthi*, was not a new one.

Except that later authors have differed as to the number of valves in the capitulum and as to the precise names of the first or upper latus and the second or carinal latus, Darwin's purely tentative nomenclature has been generally accepted without question. So far has this been the case that no one has attempted to prove the identity of either of the valves. Any doubts, however, are set at rest by the new example of *S. haworthi* (Pl. IV. fig. 2), for in that specimen the valve called the scutum has its inner surface exposed, showing the pit for the adductor muscle, thus proving that this really is the scutum.

Accepting this, it follows that the other valves would represent the upper latus, tergum, and carinal latus, and that the two linear valves would equal the carina of other cirripedes. Consequently the known valves would number ten in all. This is the same number as given by Darwin in his restoration, although the number is made up of different elements, for, apart from the carina being split, he included a rostrum. In none of the known specimens has a rostrum been noticed, and in view of the structure of the carina the improbability of a rostrum in the ordinary sense being present is great. There does not appear to be any differentiation in structure of the uppermost subscutal plates of the peduncle, and since they cannot be regarded as part of the capitular region, a rostrum or valves homologous with it cannot be said to form part of the capitulum of *Stramentum*.

Description of Shell.

Capitulum.—This is small when compared with the size and breadth of the peduncle, its length being about one-fourth that of the shell; evidently the greater part of the animal's body was lodged in the peduncle as in *Lithotrya* and *Ibla*.

Scutum subtriangular in outline, with the tergo-lateral and basal margins nearly straight and almost at right angles to each other; the growth-lines in the lower part of the valve follow the outline of the tergo-lateral and basal margins. The umbo is situated at a variable distance from the apex, and in the more advanced of the Turonian forms is about one-third the distance from the apex; in the Senonian species, *S. haworthi*, the umbo is situated at least one-half the distance from the apex even in quite young valves, and the more advanced forms have the upper half of the valve more developed. From the umbo to the apex runs a depression from which the upper part of the occludent margin rises up. In the figured specimen of *S. haworthi* and in others on the two slabs there is, on the inner surface, a deep pit for the adductor muscle.

Upper latus almost flat, having the outline of an isosceles triangle, with the scutal margin, which abuts against the tergo-lateral margin of the scutum for its whole length, rather more obliquely inclined and slightly longer than the tergal margin. The valve evidently overlapped the tergum and scutum very slightly by its edges, and the growth-lines are straight and parallel. Darwin said of this valve "The first latus now answers to the upper latus in *Scalpellum*, but it is interposed to quite an unprecedented extent between the scutum and tergum." It is, however, not more so than in the recent *Pollicipes mitella*, or in the later-discovered Cretaceous cirripede *Zeugmatolepas mockleri*, which perhaps is more comparable, since the upper part of the upper latus in *P. mitella* really overlaps the scutum and tergum for the greater part of its extent.

Tergum subtriangular, somewhat convex, with the carino-lateral and the upper occludent margins slightly rounded, and the basal margin rather more so. The growth-lines are convex, and on the upper occludent margin curve sharply upwards towards the apex.

Carinal latus obliquely triangular, rather like the upper latus, except that the tergal margin is more obliquely inclined and the basal margin more rounded, the valve being slightly inclined towards the tergum.

Carina.—This valve is of the same length as the carinal-latus and the apices of these two valves, together with that of the tergum, form the upper extremity of the capitulum. The valve is narrow, almost linear, nearly flat, about the width of the carinal plates of the peduncle, and there is a corresponding valve on the opposing side of the capitulum. Wyville Thomson has written in his description of *S. macadami*—" . . . this valve must be either one of the valves of a split carina—one of the parietes of a carina in which the tectum is undeveloped; or we must suppose the carina to have been composed of two parietes and a separate tectum, and the tectum to have been lost." In my opinion it is one of the halves of a split carina in which parietes or intra-parietes had not been developed, and the valve is of the same type of structure in *S. pulchellum* and *S. haworthi*. A ridge is invariably formed along the median line in the carinal valves of ordinary pedunculate cirripedes, and a modification such as the splitting along this line would not be unexpected. Such a secondary modification is seen in the splitting of the dorsal plate in certain species of the recent Molluscan genus *Pholas*. While such a modification of the carina is quite unique among fossil and recent cirripedes, a somewhat similar modification in the scutum is seen in certain species of the recent genus *Pœcilasma*. The scutum in that genus, as in the closely allied genus *Lepas*, has the umbo situated at the rostral angle, and the growth is entirely upwards. In *Lepas* a ridge is formed on the scutum extending from the umbo to the upper extremity of the valve, and running near and almost parallel to the occludent margin. Essentially in the same position as the ridge in *Lepas*, a suture is formed, which can be observed on both surfaces of the valve in one species of *Pœcilasma*. The development is carried a step further in other species of that genus, for in those the scutum is definitely split into two pieces.

Peduncle.—This is about three times the length of the capitulum, and in its upper part, just below the line of junction, it is rather wider than the capitulum. It is composed of ten rows of smooth calcareous scales, five on each side, forming a most beautiful loricated structure, sharply pointed at its lower extremity. There are as many as twenty-seven scales in a row in one of the specimens from Kansas, but the number naturally depends on the size and age of the individuals (see immature example depicted on Pl. IV. fig. 1 A). The summit of the peduncle is usually somewhat obliquely truncated, being lowest at the rostral end; this is

no doubt due, in some measure, to additional scales being first formed below the carinal and upper lateral valves (see under Growth, p. 77), but also to allow sufficient room for the animal's body.

Of the five rows of scales the three inner series are composed of nearly equal scales, much elongate transversely, and are about as wide as the carinal-latus, upper latus, and scutum, below which valves they are situated, so that the lines of junction of the peduncular scales correspond more or less with those of the capitular plates mentioned. The scales are closely imbricating, the middle series intersecting those on either side; and those two series are again in turn intersected by the outer subcarinal and subscutal scales, which are in line with the middle series; the much smaller outer scales simply meet those on the opposite side of the shell and do not overlap or intersect them in any way. Consequent on this arrangement of the peduncular scales, alternate whorls are formed, one being composed of the large median plates and the small outer subcarinal and subscutal scales, making in all six rows; and above and below whorls are formed of the two large lateral plates, making four rows. The structure and relationship to each other of the peduncle-scales, both of the inner and outer surface, is well shown in the specimens depicted in fig. 2 of Plates III. & IV.

The Shell when complete.—While Darwin erroneously thought that the shell in this genus had a keeled carina and rostrum, he was of the opinion that the lateral valves of the capitulum, as well as the plates of the peduncle, must have been present on both sides of the shell.

With regard to the lateral capitular valves, excepting the carina, decisive proof of their paired nature has been given by Whiteaves, for in the holotype of *S. canadensis* (1889, p. 190, pl. xxvi. figs. 4, 4 *a*) the upper lateral series of valves has been either partially or completely broken away, showing underneath the inner surface of the scutum, upper latus, tergum, and carinal latus. In other specimens figured by Fritsch (1887) and H. Woodward (1908) slight displacement of the valves has shown the inner surface of an underlying scutum. It is therefore certain that the whole of the capitular valves were paired, for, in addition to the lateral valves, the valves homologous with the carina can be shown to be paired, not only in *S. pulchellum*, but in *S. haworthi*. The split carina is very clearly shown in the specimen described as *S. macalami*, for fortunately a slight displacement of the upper plate shows part of the inner surface of the opposing plate along its entire outer margin: it is a pity that

the specimen arrived too late for illustration in this paper, for it shows this character more readily than in the specimen originally figured as *S. darwini* or in *S. haworthi*.

As to the peduncular plates, the only evidence so far given of an opposing series is that the under row of subscutal plates are to be seen projecting from beneath the upper row in the figured example of *S. pulchellum* (Pl. III. fig. 2). One or two of the subcarinal plates can also be seen projecting from beneath the upper series in the same specimen. Dr. Woodward had the chalk removed from beneath that specimen, and did not find any evidence of an opposing series of the three median rows of peduncle-plates. He thereupon suggested that they were not developed on the under side of the peduncle, which was attached to the shell of the ammonite along the margins of the under row of subscutal and carinal plates.

When comparing *S. expansum* with *S. pulchellum* (Withers, 1911, p. 29), attention was incidentally drawn to the fact that certain of the specimens figured by Fritsch and of those described by Woodward, some had the scutum on the right hand and others on the left (see also Pls. III. & IV.). While it was probable from this that the whole of the peduncular plates were developed on both sides of the shell, it was not conclusive proof, since it might have been quite accidental which side of the shell was developed uppermost, in the same way that certain lobsters have the "crushing chela" developed on the right side and others on the left.

The case of the cirripede *Verruca* might also have been mentioned, for in that genus it seems to be quite a chance whether the movable scutum and tergum are developed on the right or left side of the shell.

A detailed examination of one of the specimens described as *S. darwini* (Pl. III. fig. 1 A), not figured by Dr. H. Woodward, was rewarded by the discovery that the plates of the peduncle were actually present on both sides. Some of the subcarinal and carino-lateral plates of the peduncle were broken away near the base of the capitulum, and although nothing but chalk appeared to be there, removal of the chalk revealed the presence of the inner surface of the opposing plates of the subcarinal and carino-lateral series. Further evidence is afforded by the example of *S. haworthi* (Pl. IV. fig. 2), for, although it represents one side of an almost entire shell showing its inner surface, there are in many places preserved *in situ* the peduncular plates of the other side of the shell, especially the series of the carino-lateral plates. Taken together these two specimens conclu-

sively prove that the shell of *Stramentum* was composed of ten vertical series of plates, five on each side of the shell. Since there were no keeled plates to the capitulum, and the subcarinal and subscutal plates of the peduncle did not intersect or overlap each other, the shell could be readily divided along the median line thus formed without destroying any one plate. This is exemplified by the fact that on the two slabs of chalk from Kansas on which about thirty individuals are preserved, no less than twenty-eight of them consist of one side of the shell more or less complete, and show the inner surface. The other side of these shells was probably on the counterpart of the slab, or had floated away after the death of the animal and decomposition of the soft parts. In individual cases one side of the shell might easily be torn away by some animal, as suggested by Darwin.

Growth.—New scales of the peduncle are apparently first formed round its summit towards its carinal end, for, as pointed out by Darwin, there is in the holotype of *S. pulchellum* one more scale under the second latus and one more under the first latus than under the scutum. In the figured specimen referred to *S. darwini* by Dr. Woodward, there appears to be two more scales in both the series than in that under the scutum. One very young example of *S. haworthi* is here figured (Pl. IV. fig. 1 A), measuring 1·2 mm. in length and consisting of twelve plates only to its nearly complete peduncle.

Attachment.—Darwin was of the opinion that in this genus the attachment was probably by one lateral face of the lower part of the peduncle, and was effected either by the overflow of the cementing material from the two central original orifices or by cement poured out of orifices situated on one side of the peduncle. He found no difficulty in the peduncle ending in so fine a point, for he stated that in *Scalpellum vulgare* the peduncle, when carefully dissected from the coralline to which it is attached, is often found to end in a much finer point and to be symmetrically attached to the branch by its narrow rostral margin.

Dr. H. Woodward (1908, pp. 498 *et seq.*), however, considered that the peduncle was attached along the whole extent of the subscutal and subcarinal scales, and that the mode of growth of *Stramentum* was always prone. He concluded, since Darwin mentioned that *S. pulchellum* was found "embedded outside the cast of an ammonite," that "he did not quite realize it was adhering to the shell and parasitic upon the ammonite, as *Coronula balanaris* attaches itself to the skin of the whale, and *Chelonibia testudinaria* and

C. caretta affix themselves to the surface of the turtle to-day."

Although many specimens have been found attached to ammonites, in no case am I aware that they are attached to the actual shell, the ammonite being represented by a chalk-cast. Whatever the mode of attachment, it cannot be said to be truly comparable to the mode of attachment of *Coronula* or *Chelonibia*. To my mind it is more probable that the shell of *Stramentum* was attached only by the extremity of its peduncle, and was pressed against the side of the ammonite during fossilization. While the Kansas examples of *Stramentum haworthi* on the two slabs in the Geological Department of the British Museum appear to have been attached to a strap-like organism, of which only a stain remains, the type was said by Logan to be attached to a shell of *Ostrea congesta* by the extremity of its peduncle. Dr. H. Woodward appears to have doubted this, but there is a photograph of the type exhibited with the above-mentioned slabs in the British Museum, and this conclusively shows that that specimen, at any rate, was so attached.

Comparison with other Genera and Phylogenetic Position.

The structure of *Stramentum* as now revealed by the new material certainly shows it to be more anomalous than was thought. So far as our knowledge goes, it differs from all other cirripedes, both recent and fossil, in that all the valves of the capitulum are paired, and that the outermost or subcarinal and subscutal rows of peduncular plates do not overlap or intersect each other. The shell could therefore readily be divided along the sutures formed along the carinal and scutal margins. It further differs from all recent cirripedes in the marked disparity in size of the lateral plates of the peduncle as compared with those of the subscutal and subcarinal series. There appears to be a similar disposition of the peduncular plates in the Cretaceous genera *Squama* (Senonian) and *Loriculina* (Senonian). How far these genera are related it is difficult to say, for we know so little of their precise structure. Further investigation may prove *Loriculina* to be congeneric with *Stramentum*, for the presence of a comparatively large rostrum in the figure of the genotype may not be substantiated. *Squama*, which is so far confined to the Kansas chalk and occurs at a slightly lower horizon than *Stramentum haworthi*, is known only from the inadequate figures and descriptions of Logan. When the precise structure of the genus is known it will

probably be found to be quite as interesting as *Stramentum*. In addition to the valves known in the capitulum of *Stramentum*, *Squama* is said to possess a rostrum, subrostrum, and subcarina, but whether these latter valves are keeled or whether they have the same structure as the carina in *Stramentum* is not known.

Stramentum is known in the Cenomanian only by one specimen from Syria, but is comparatively common in the Turonian of Europe. It lingers on to the Senonian in Europe, but is exceedingly rare, while in the Senonian Kansas Chalk of America it is common. We have, therefore, to look in the earlier Cretaceous and Upper Jurassic rocks for the ancestors of *Stramentum*. By some authors *Stramentum* is considered to be a derivative from the Jurassic genus *Archæolepas*, but it must not be overlooked that that genus is not entirely confined to the Jurassic, since one or two species range into the Lower Cretaceous.

Archæolepas has a capitulum of six plates only, consisting of paired scuta, paired terga, and a carina and rostrum of the type seen in the Scalpellidæ (*Scillælepas*), although the carina is much reduced in size. The earliest form, namely, the genotype *Archæolepas redtenbacheri*, is known to me only by figures, which would appear to be unreliable, since they differ in the number of vertical rows of peduncular plates. Zittel's figure is probably more correct and shows five rows, and the disposition of the plates resembles that of *Stramentum* more than any other form of cirripede. There is a close resemblance in the shell of *Archæolepas* (*A. redtenbacheri*) to that of *Stramentum*, and a further point in common is the reduced carina. The general structure of the shell of that early form of *Archæolepas* also points to the probability that, as in *Stramentum*, the greater part of the animal's body was lodged in the peduncle. In this connexion it is interesting that a much more definite peduncle is developed in the Portlandian species *Pollicipes royeri*, which is undoubtedly an *Archæolepas*; and in the Cretaceous (Neocomian) *Archæolepas decora*, the peduncle is well defined and almost twice as long as the capitulum. There appears, therefore, to be some relation in *Archæolepas* between the geological age of the form and the degree of differentiation of the peduncle from the capitulum.

It might well be that *Archæolepas* and *Stramentum* were originally derived from the same stock, but the two forms were certainly well differentiated in the Cretaceous. *Archæolepas* evidently developed into a form with a well-defined peduncle, and there is no doubt that it represents one of the

ancestors of the Scalpellidæ. *Stramentum*, on the other hand, constitutes a highly specialized and aberrant form. Instead of developing a definite peduncle, it specialized in the disposition and arrangement of its plates to form a completely armoured shell. When attached to its object, usually an ammonite, the cirri would not have nearly so much sweep and freedom of movement as in a pedunculate form. The subsequent splitting of the carina, and the non-intersection or overlap of the plates along the outer margins of the shell, was no doubt evolved to obtain that freedom of movement, and this specialization, while giving a temporary advantage, probably led to its extinction under changing conditions; and the fact that the two sides of the shell were so easily parted would render it especially vulnerable to its enemies.

Prof. Gruvel (1905), who has been followed by later authors, has a different conception of the phylogenetic position of *Stramentum* (= *Loricula*). He considers that the first remains of cirripedes are represented by the fossils *Turrilepas*, H. Woodward, and *Plumulites*, Barrande, and that those fossils constitute the complete imbricated covering of a primitive cirripede. The animal may be said to have been enclosed in a scaly cylinder, which afforded protection to the appendages and soft parts. He considered that later the upper row of plates were more specially developed to form the capitulum and that the remaining rows remained undifferentiated and served to form the peduncle. *Loricula* is supposed to represent this second stage, and Prof. Gruvel has given some very convincing figures, which have been reproduced in the text-books, as to the structural relationship of those two forms. He does not refer at all to *Archæolepas* or any other Jurassic cirripede.

Apart from the fact that *Turrilepas* may not be a cirripede, it is quite clear that Prof. Gruvel has misunderstood the structure of the example of *T. wrightianus* figured by Dr. H. Woodward, and on which he based his figure. Instead of *Turrilepas* having a laterally flattened shell with five rows of plates on either side as given in Gruvel's figure (see text-fig. 1 *a*, *b*), the shell is subtriangular in transverse section (see text-fig. 1 *a'*) and there are four rows of plates only. In fact, the real structure of the two forms is so fundamentally different that it is difficult to imagine that there can be any relationship between them.

While it is difficult therefore to see how *Turrilepas* could give rise to a form like *Loricula* (text-fig. 2), there is little doubt that certain of the stalked cirripedes were evolved

from other cirripedes in which the capitulum and peduncle were not well defined. This is borne out not only by the postlarval development of certain recent pedunculate cirripedes, but by the forms of *Archæolepas*. Such a modification was no doubt independently developed in other lines of

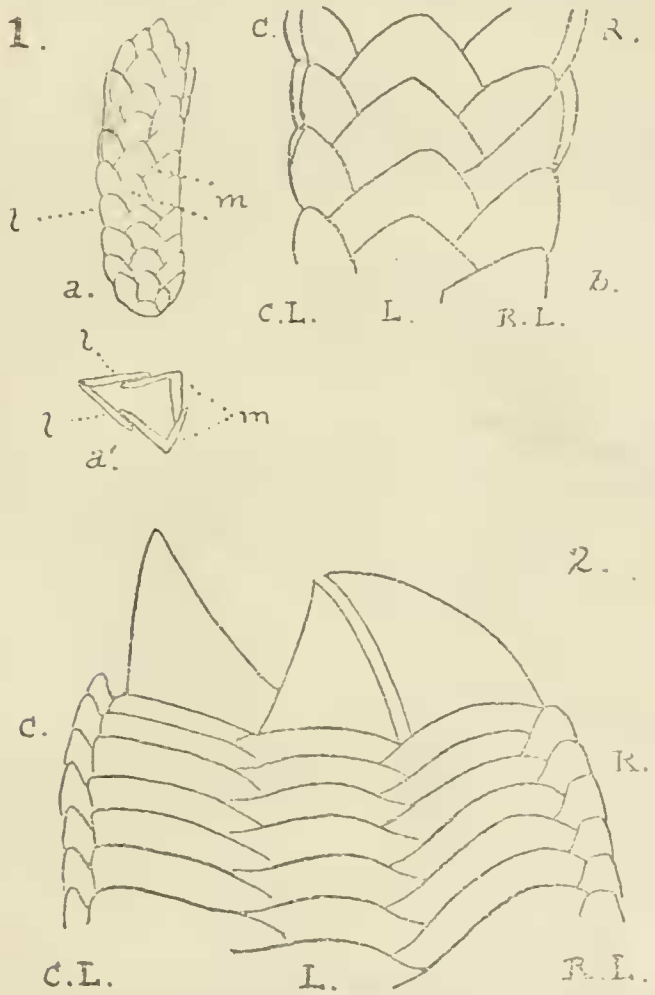

Fig. 1.—*Turrilepas wrightianus*, H. Woodward. *a*, shell viewed from back and left side. *a'*, transverse section of shell: *m*, median plates; *l*, lateral plates. *b*, portion of shell enlarged. (Figs. *a*, *b*, after Gruvel; *a'*, after Withers.)

Fig. 2.—*Strumentum pulchellum*, G. B. Sowerby, Jun., sp., showing mode of imbrication of peduncular scales. (After Gruvel.) C., carinal scales; C.L., carino-lateral scales; L., lateral scales; R.L., rostro-lateral scales; R., rostral scales.

descent. Having arrived at the pedunculated stage, several forms have independently reduced the peduncle and eventually assumed the sessile condition. This has been shown in the case of the Verrucidæ, and there can be no doubt that

the Balanidæ have reached the sessile condition by another route.

In conclusion, I wish to thank Dr. F. A. Bather, Dr. W. T. Calman, and Prof. Grenville A. J. Cole for assistance in connection with this paper.

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EXPLANATION OF THE PLATES.

Plate III.

Stramentum pulchellum, G. B. Sowerby, Jun., sp. Turonian (*Rhynchonella cuvieri*-zone): Cuxton, near Rochester, Kent.

Fig. 1. Remains of two individuals with the outer surface of the *right* side of the shell uppermost. A, represents an incomplete shell showing the greater part of a peduncle with the *right scutum* (*s*) of the capitulum in position, underneath which can just be seen the edge of the *left scutum* (*s'*). The remaining capitular plates of the *right* side, as well as many of the subcarinal and carino-lateral scales of the upper part of the peduncle have been broken away, thus leaving exposed the inner surface of the *left tergum* (*t'*), *left carinal-latus* (*cl'*), and about eight of the *left carino-lateral scales* (*cls'*). B, represents part of the right side of a peduncle, at the base of which can be seen the inner surface of several scales of the *left* side of the shell. Circa × 2 diam.

Fig. 2. An almost complete shell showing the outer surface of the *left* side. All the capitular plates—*carina, carinal-latus, tergum,*

upper latus, and *scutum* are present, and the inner surface of the *right scutum* (*s*) and that of many of the subscutal scales of the peduncle can be seen projecting from beneath the opposing series. Circa × 2 diam.

(Figs. 1 and 2 represent the three syntypes of *Loricula darwini*, H. Woodward, all three shells being much flattened transversely.)

Fig. 3. A shell (the holotype of *L. pulchella*, G. B. Sowerby, Jun.) with the outer surface of the *left* side uppermost, and showing the scutum (*s'*), upper latus (*ul'*), and carinal-latus (*cl'*), the *carina* and *tergum* being absent from the capitulum. This shell has a much greater transverse convexity than those represented by figs. 1 and 2. Circa × 3 diam.

PLATE IV.

Stramentum haworthi, S. W. Williston, sp. Senonian (Niobrara series): Kansas, U.S.A.

Fig. 1. Remains of two immature individuals. A, the *right* side of a shell with the inner surface uppermost, the carina only missing of the capitular valves, and the scutum (*s*) shows the adductor muscle-pit; the peduncle has only twelve scales. B, the lower part of a peduncle with its inner surface exposed. C, capitular valves probably belonging to B, and consisting of the linear *carina* (*c*), the *right carinal-latus* (*cl*), *left upper latus* showing inner surface, and paired *scuta* (*s*), the *left scutum* being broken and exposing the *right scutum* beneath. Circa × 6 diam.

Fig. 2. A fine example of a shell lying on its *right* side, and owing to the displacement of the capitular valves both the *left* and *right* valves can be seen, the *right scutum* (*s*) showing the adductor muscle-pit; the peduncle in the main shows the inner surface of the three median series of scales of the *right* side of the shell, except that the whole of the *left carino-lateral* scales (*cls'*) are present. Circa × 4·5 diam.

Fig. 3. A shell with the *right* side uppermost and showing the whole of the capitular valves, the *carina* (*c*) being somewhat incomplete. Circa × 4·5 diam.

VII.—*On Indo-Chinese Hymenoptera collected by R. Vitalis de Salvaza.*—IV. By ROWLAND E. TURNER, F.Z.S., F.E.S.

Superfamily TENTHREDINOIDEA.

Family Tenthredinidæ.

Subfamily *CIMBICINÆ*.

Clavellaria (*Euclavellaria*) *marginata*, sp. n.

♀. Fusco-nigra; capite thoraceque obscure nigro-chalceis; propodeo nigro-æneo, apice angusto ochraceo-fasciato; tergitis nigris, opacis, apice anguste ochraceo-fasciatis, sternito apicali